Forecasting Inflation In China

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ABSTRACT

China is the world's second largest economy, has sustained strong growth rates for an extended period of time, and is a prime destination for international investors. It is therefore important for researchers to correctly forecast key macroeconomic variables, such as economic growth and inflation within the Chinese economy. Forecasts of inflation, in particular, are important for domestic production, export competitiveness, business planning and for international investors. A section of the literature has assessed models to explain and forecast inflation – within this literature, the role of deviations of output from equilibrium output (Phillips Curve models specified as output gap models) and the role of monetary policy in explaining inflation in China have been of great interest. This paper assesses atheoretic and structural models to explain Chinese inflation and tests the forecasting ability of these models. The findings show that money is not as important in explaining inflation as the output gap. The output gap approach also provides the best forecasts of inflation for the out-of-sample period 2003-2012. Models based on past information alone cannot beat the output gap models.

Keywords: Inflation; Forecasting Models; Price Gap Models

INTRODUCTION

China is currently the world's second largest economy and many forecasts indicate that it is poised to become the world's largest economy with the next two decades or so. International investors flock to Chinese markets to invest in stocks, bonds and the real estate markets. Chinese goods and services are highly competitive in international markets and China is also a large importer of goods and services from the rest of the world. Thus, it is of prime importance to understand and forecast the inflation rates in China. Accurate forecasts are not only important in business planning and enterprise, but are also key in understanding ripple effects in international markets. A rise in inflation rates in China is worrisome from the point of view of imported inflation, but it is also important in affecting the prices of substitute assets. Recently, gold futures have risen in the expectation that rising inflation in China would increase demand for gold as an asset (WSJ, July 9, 2013). However, in general, inflation rates in China are still relatively stable and the economy enjoys high rates of growth with reasonably stable inflation. Given China's continued growth prospects, it becomes ever more important to accurately forecast macroeconomic phenomena, such as inflation, in order to assess China's continued role for investors and in international business.

Money supply is currently increasing at above expected rates in China as the monetary authorities work to achieve continued steady growth. Thus the link between money and inflation becomes a key area of focus. The quantity theory of money and the price gap models that are derived from the quantity theory of money then provide a clear link between money growth and inflation in an economy. This paper assesses different inflation forecasting models to see which models fit the data best. The price gap model and a Phillips Curve type output gap model are compared to atheoretic models based on past information alone. The models are thereafter tested as to their forecasting ability.

The literature review section discusses studies relevant to the study; the sample, data and methodology section discusses the study sample, the data sources and presents the models to be studied in this paper; the findings section presents the results of the analyses, and the robustness tests for this study; and the paper ends with concluding remarks and policy implications.

LITERATURE REVIEW

In general, since the 1970s when economic reform began in China, the economy has seen sustained periods of growth and low inflation and has even experienced deflationary periods (Gerlach and Peng, 2006). At the current time as economic growth rates in China weaken slightly, the monetary authorities remain committed to holding a steady pattern of growth through monetary and fiscal intervention. As the growth of money supply increases, the issue of inflation pressures arises. Monetary expansion in China has, in the past, through the investment channel, fueled increased inflation in the 1980s (Ha, et. al, 2003). It is therefore of prime importance to model the relationship between money and prices when explaining inflation in China. Zhang and Clovis (2010) find that monetary policy is significant in explaining structural change in China and they stress the importance of vigilance over Chinese inflation. Whereas Zhang and Clovis employ a VAR approach to studying the link between the real economy, prices, and monetary policy, an alternate approach lies in the price gap models. The price gap models are dependent on the quantity theory of money and form a nice link between real economic activity, money, and inflation in the short run.

The 1980s saw a concerted effort in price reform in China (Chow, 1987) as the existing price system did not correctly signal changes in market forces. Chow (1987) further assesses the performance of the quantity theory of money in explaining the price level over the period 1952 to 1983 and finds that it provides a good fit of retail prices in China. Interestingly, some past studies on inflation in China indicate that money supply is not critical to explaining inflation in China. Chen et al. (2009) find that inflation in China is not affected by any of the money measures – M0, M1 or M2. The authors do, however, highlight money supply as a medium term goal of Chinese monetary policy. In contrast, Jianfei (2009) finds that money growth is the primary cause of inflation in China and models that build money supply into forecasting inflation outperform models that do not include money supply. Similarly, Zhiyong (2008) finds that inflation in China is explained, to a greater extent, by money supply changes than by rising wages. According to that study, then, the cost push explanation for inflation in China does not seem to have as much support as the demand pull inflation explanation.

Forecasting inflation accurately in any country is very important for policy-making purposes – in the case of China, a target inflation rate is one of the key macroeconomic policy goals. Chinese inflation rates are also very influential on other economies in the world. For example, as discussed earlier, Chinese demand for gold and Chinese inflation rates affect world gold prices and gold futures. Chinese inflation would also affect import prices in the United States and could cause imported inflation. The price gap model originally designed by Hallman, Porter and Small (1991) is composed of a summation of a velocity gap (derived from the quantity theory of money) and an output gap. The question then arises as to the importance of output gaps when explaining inflation in China. Burdekin and Siklos (2008) show that macroeconomic policy from the People's Bank of China is reactive to the gap between the current nominal level of GDP and a pre-specified target level of nominal GDP. Funke (2006) has adopted a New Keynesian Phillips Curve approach to inflation modeling and finds that this approach performs consistently with Chinese data. Mehrotra and Sanchez-Fung (2008) run fifteen different models for forecasting inflation and find that structural models, such as the VAR approach, the Phillips Curve model, and larger time series models, marginally outperform the very simple time series models.

Price Gap Approach

The basic price gap model has its roots in the quantity theory of money and is based on the P* model developed by the Federal Reserve (Hallman, Porter and Small, 1991). Hallman, Porter and Small (1991) present the development of the model, which is based on the equation of exchange $MV = PY$. M represents M2 (broad money stock) while V is the velocity of the M2 measure of money. Prices are measured using a key price index. In this case, P represents the GDP deflator and Y is a measure of output in the economy. From this central equation, the next step involves solving for the price level in the aggregate economy: $P = M(V/Y)$. The velocity of M2 and the measure of output are assumed to display cyclical behavior over time. Thus, measures of long-run equilibrium velocity and output are needed. The equilibrium values for velocity and output are, for the purposes of this paper, measured as the long-run means and are entered into the equation of exchange. Thereafter, the equilibrium price level is solved for. This step yields $P^* = M(V^*/Y^*)$. Thus, P^* represents the level of prices that is proportional to the money stock per unit of long-run output. Taking natural logs of the two-price level equations yields equations 1 and 2 below.

$$\ln P = \ln M + \ln V - \ln Y \tag{1}$$

$$\ln P^* = \ln M + \ln V^* - \ln Y^* \tag{2}$$

Subtracting equation 2 from 1 then yields a price gap equation as follows:

$$(\ln P - \ln P^*) = (\ln V - \ln V^*) + (\ln Y^* - \ln Y) \tag{3}$$

Equation (4) can then be represented as follows where all variables are in natural logs:

$$(p - p^*) = (v - v^*) + (y^* - y) \tag{4}$$

In order to account for the persistence of inflation over time periods, the model can then be extended to include lags of inflation. In generalized form, then, the final price gap model can be presented in the following condensed form:

$$\Delta\pi_t = \alpha\,(p - p^*)_{t-1} + \sum_{i=1}^{k} \beta_i\, \Delta\pi_{t-i} \tag{5}$$

The price gap model has been well tested with data from around the world. Kamal (2014) tests the model with US data from 1959 to 2012 and compares the price gap model with naïve forecasts from autoregressive models and also compares the price gap model with an output gap model. Kamal finds that the price gap model out-performs the other models over the 1-quarter and 4-quarter ahead forecast horizons but loses some of its forecasting power when core CPI is used as an inflation measure. Hallman, Porter and Small (1991) found that the P* model fitted US data and performed reasonably well on out-of-sample forecasts. Using data from OECD countries, Hoeller and Poret (1991) found that the P* model fitted past inflation values relatively well but did not perform very well over short-term forecasting horizons. Kool and Tatom (1994) tested a fixed exchange rate P* approach for countries that have a fixed exchange rate regime and found support for the model within this scenario. The study, which was a pre-Eurozone study with data up to the 1990s, tested their model on five European economies that pegged their currencies to the German Deutschemark.

Recently, the P* or price gap approach has become popular with emerging market and developing country studies. Habibullah and Smith (1998) test the model with data from the Philippines. Using data from 1981:1 to 1994:4, the authors test narrow and broad money aggregates within the price gap formulation and find that the model fits the data quite well. Nachane and Lakshmi (2002) apply the price gap model to Indian data over a period of four decades and find that the mode outperforms an ARMA-type model. Ozdemir and Saygili (2009) find support for the price gap model using Turkish data. Finally, Gonzalez, et al (2009) test a money gap form of the P* model on Colombia data and find that the money gap is more important in explaining inflation than the output gap.

SAMPLE, DATA AND METHODOLOGY

The period in focus in this paper is 1977 to 2012. Annual data is used and the data is sourced from the World Development Indicators database from the World Bank. Inflation is measured as the percentage annual change in the GDP deflator. Money stock is represented by M2 (money and quasi money). Y is represented by real GDP data. All data are measured in local currency units. Figure 1 shows the historical behavior of annual inflation in China (as measured by the percentage change in the annual GDP deflator). The data shows that inflation has reduced volatility since the end of the 1990s.

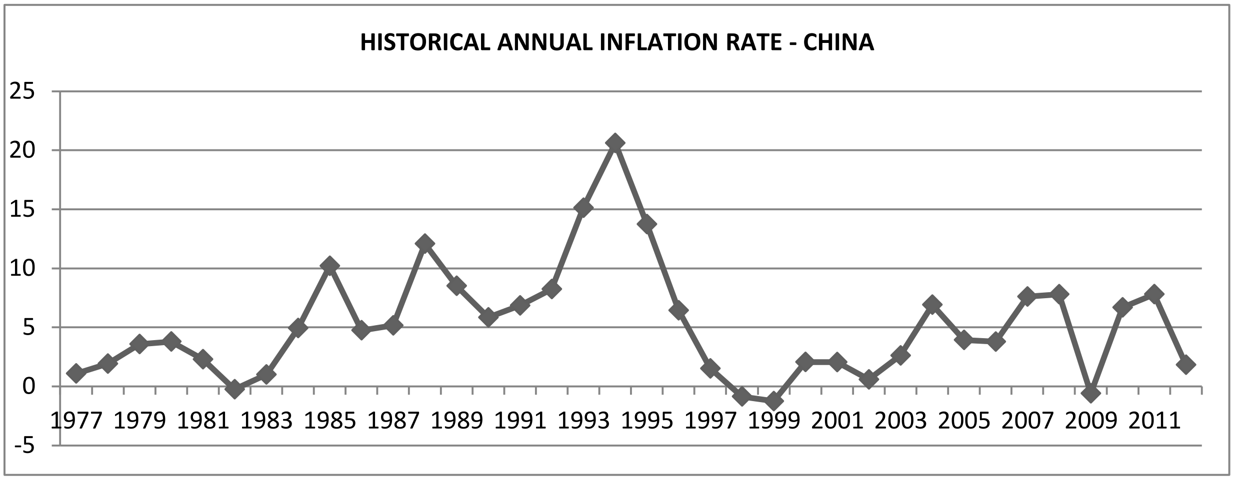

Figure 1: Historical Inflation Rate (1977-2012) – Percentage Change In Annual GDP Deflator
Source: World Development Indicators (data.worldbank.org)

The full data period for this study is 1977 to 2012, and this period is split into an in-sample period from 1977 to 2002 and an out-of-sample forecast period from 2003 to 2012. The complete set of econometric models tested in this paper consists of two benchmark autoregressive processes, a price gap model and a Phillips Curve type model. The Phillips Curve type model is represented by the more modern output gap model, rather than the traditional unemployment gap approach. The models are represented by equations 6-9. The dependent variable, in all cases, is measured as accelerations of inflation and any independent lags of inflation are also modeled in accelerations to mitigate the stationarity issue. The number of lags is determined through the appropriate econometric techniques. The models, based on past information, are an AR (2) model and an ARMA (1,1) model. These two models form the benchmarks for the study. The price gap approach is modeled with two lags of the change in inflation and the output gap model is modeled with 2 lags of the change in inflation.

$$\Delta\pi_t = \delta + \beta_1 \Delta\pi_{t-1} + \beta_2 \Delta\pi_{t-2} + \varepsilon_t \tag{6}$$

$$\Delta\pi_t = \delta + \beta_1 \Delta\pi_{t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t \tag{7}$$

$$\Delta\pi_t = \alpha\,(\text{p-p*})_{t-1} + \beta_1 \Delta\pi_{t-1} + \beta_2 \Delta\pi_{t-2} + \varepsilon_t \tag{8}$$

$$\Delta\pi_t = \alpha\,(\text{y*-y})_{t-1} + \beta_1 \Delta\pi_{t-1} + \beta_2 \Delta\pi_{t-2} + \varepsilon_t \tag{9}$$

FINDINGS

Table 1 shows the results of the in-sample regressions for the four models over the in-sample period 1977 to 2002. The results indicate that the simple atheoretic models, based on autoregressive processes, are not the best fit for the data. Changes in inflation in China are best explained by a Phillips curve type approach, as modeled by the output gap model, where the output gap is significant and has the expected sign. This reflects findings by other researchers as discussed earlier in this paper – examples are findings by Burdekin and Siklos (2008), Funke (2006) and Mehrotra and Sanchez-Fung (2008) who show that deviations from equilibrium GDP and structural models of this variety are important in explaining inflation in China.

The negative sign on the output gap is as expected – when the output gap is positive, the change in inflation is expected to be negative (expected deflation) as the economy underperforms relative to the equilibrium level of output in the economy. The output gap also displays the highest adjusted R-squared values over the in-sample regression period. The price gap in the price gap model is not significant, and this is indicative that monetary policy does not seem to explain the change in inflation - this reflects earlier findings such as those by Chen et al. (2009) who find that money measures do not explain inflation in China.

Table 1: In-Sample Regression Results (Inflation As Measured By the GDP Deflator)

Model	AR(2)	Arma(1,1)	Price Gap Model	Output Gap Model
δ	-0.11 (-0.14)	0.22 (0.15)	-2.25 (-0.75)	**-6.47** **(-2.59)****
$(p-p^*)_{t-1}$			-13.53 (-0.74)	
$(y^*-y)_{t-1}$				**-68.90** **(-2.65)****
$\Delta\pi_{t-1}$	0.33 (1.64)	**-0.42** **(-1.93)***	0.37 (1.75)	0.26 (1.44)
$\Delta\pi_{t-2}$	**-0.41** **(-2.02)***		**-0.44** **(-2.11)****	**-0.35** **(-1.92)***
ε_{t-1}		**0.97** **(17.58)*****		
Adjusted R-squared	0.14	0.21	0.12	0.34

*** t-statistics significant at 1% level or less, ** t-statistics significant at 5% level or less, * t-statistics significant at 10% level or less. Table 1 shows the regressions results for the in-sample period from 1977 to 2002, using annual data sourced from the World Bank's World Development Indicators. The dependent variable is the change in the rate of inflation. (p-p*) is the price gap, where p is the current price level in the economy, and p* is the level of prices that is proportional to the money stock per unit of potential output. (y*-y) is the output gap, where y* is the long run mean level of real GDP, and y is the current level of real GDP. $\Delta\pi$ represents the change in inflation rate.

As mentioned previously, the data frequency is annual and the out-of-sample forecast period is 2003-2012. The two forecast horizons are one period ahead and three periods ahead. This allows for the assessment of the forecasting power of these models over the short and medium term horizons. Following the approach by Mehrotra and Sanchez-Fung (2008), the forecasting ability of the various models is tested through the use of the relative root mean square forecast errors (RMSFEs). The results are presented in Table 2 – the benchmark model is the naïve AR (2) model, which has a RMSFE value of 1.00. The findings show that the autoregressive processes provide very similar forecasts but cannot be beaten by the Phillips Curve model, which has the lowest RMSFE values over both forecast horizons. The model thus establishes itself as a useful policy formulation tool, as macroeconomic stabilization policy is designed for both short-term and medium horizons. The price gap model is outperformed by all the other models, further cementing the finding that money does not play a significant role in explaining short- to medium-term inflation in China.

Table 2: Relative RMSFE Values for 1-Period-Ahead and 3-Period-Ahead Forecasts (Inflation Measures Based On GDP Deflator Values) - Forecast Period Is 2003-2012

	k = 1	k = 3
AR(2) APPROACH	1.00	1.00
ARMA(1,1) APPROACH	1.00	1.01
PRICE GAP MODEL	1.05	1.05
PHILLIPS CURVE APPROACH	0.89	0.86

For robustness purposes, all four models are then tested with a different measure of inflation - the Consumer Price Index. This data is also sourced from the World Bank's World Development Indicators. The time span available for this variable is from 1987 onwards. The simple autoregressive model, the price gap model and the output gap model are then tested using this new data set from 1987 to 2012. The in-sample period begins in 1987 and extends up to 2002. The out-of-sample period is as before - 2003 to 2012. The in-sample regression results are presented in Table 3 and mirror those found earlier – the data supports the output gap model to a greater extent than the other models. The price gap model again performs poorly, indicating that money does not play a key role in explaining inflation in China. To assess the robustness of the results when the inflation measure is the consumer price index, forecasting over the one period ahead and three period ahead horizons is done. The results of the robustness exercise are presented in Table 4. The results indicate that the output gap model maintains the lowest relative RMSFE, even when the measure of inflation is changed, thus reflecting its usability for policy formulation.

In fact, the output gap model actually displays lower forecast errors in the medium-term horizon as compared to the short-term horizon. As policy makers base their forecasts on consumer spending and prices, the ability to harness a model that has good explanatory power over the consumer price index is important. Moreover, policymakers typically set macroeconomic targets that are both short and medium term, and since the output gap model forecast errors fall in the medium-term horizon when inflation is measured by the consumer price index, it is a very useful policy formulation tool.

Table 3: In-Sample Regression Results (Inflation As Measured By the Consumer Price Index)

Model	AR(2)	Price Gap Model	Output Gap Model
δ	-1.20 (-0.69)	0.60 (0.09)	**-15.44** **(-2.48)****
$(p\text{-}p^*)_{t-1}$		12.05 (0.27)	
$(y^*\text{-}y)_{t-1}$			**-152.20** **(-2.35)****
$\Delta\pi_{t-1}$	0.38 (1.41)	0.35 (1.20)	0.12 (0.48)
$\Delta\pi_{t-2}$	**-0.47** **(-1.99)***	**-0.47** **(-1.89)***	-0.26 (-1.22)
ε_{t-1}			
Adjusted R-squared	0.19	0.11	0.44

*** t-statistics significant at 1% level or less, ** t-statistics significant at 5% level or less, * t-statistics significant at 10% level or less. Table 1 shows the regressions results for the in-sample period from 1977 to 2002, using annual data sourced from the World Bank's World Development Indicators. The dependent variable is the change in the rate of inflation. (p-p*) is the price gap, where p is the current price level in the economy, and p* is the level of prices that is proportional to the money stock per unit of potential output. (y*-y) is the output gap, where y* is the long run mean level of real GDP, and y is the current level of real GDP. $\Delta\pi$ represents the change in inflation rate.

Table 4: Relative RMSFE Values for 1-Period-Ahead and 3-Period-Ahead Forecasts (Inflation Measures Based On Consumer Price Index Values) - Forecast Period Is 2003-2012

	k = 1	k = 3
AR(2) APPROACH	1.00	1.00
PRICE GAP MODEL	0.92	0.91
PHILLIPS CURVE APPROACH	0.85	0.75

CONCLUSION

Given the current and increasing importance of the Chinese economy in the world trade system and as a destination for international savings and investment, forecasting of macroeconomic variables, such as inflation, becomes vitally important for both businesses and individuals. Inflation in China has effects on international asset prices as well. Recent data indicates that the price of gold futures is positively related to inflation in China. In this paper, several different econometric models are tested to see which model yields the best forecast for inflation. The four models tested in the paper are the price gap model, an output gap model, an AR (2) model, and an ARMA (1,1) model. The data are sourced from the World Bank's World Development Indicators and the time period in focus is 1977 to 2012. The data frequency is annual. The in-sample regression period is 1977 to 2002. The models are then used to produce rolling forecasts of inflation over the time period 2003 to 2012. The results indicate that money is not as important in explaining inflation in China as the GDP gap. The price gap in the P* price gap model is insignificant at all times. Thus, the data supports the output gap model to a significantly greater extent than the price gap model. The output gap is significant and has the expected negative sign. This is because of the inverse relationship between the sign of the gap and the change in inflation. The out-of-sample rolling forecasts show that the output gap model provides the best inflation forecasts for the one period ahead and three periods ahead forecast horizons over the time period 2003 to 2012. Models based on past information alone cannot beat the output gap model. This result is robust to different measures of inflation – the output gap model's forecasts improve when inflation is measured using the consumer price index as opposed to the GDP deflator.

The results are important for policy formulation purposes. The findings indicate that inflation in China is explained, to a greater extent, by deviations from equilibrium output than by the role of broad money velocity, and the output gap models yield the lowest relative inflation forecast errors over the short and medium term forecast horizons. The output gap also maintains its explanatory power when the measure of inflation is the consumer price index. In fact, when inflation is measured using the consumer price index, the output gap model has lower forecast errors over the medium term horizon as compared to the short-term horizon. Policy targets are typically both short- and medium-term. From a policymaking perspective, therefore, the output gap model thus has an important role in macroeconomic policy discussions and forecasting.

AUTHOR INFORMATION

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